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be prepared to forward any important astronomical message, limited to *ten* words, which may be sent to him for this purpose from the principal European astronomers.

Royal Observatory, Greenwich,
April 8, 1873.

Chinese Observations of Solar Spots. By Mr. John Williams.

Having lately become possessed of a copy of the celebrated Encyclopædia of Ma Twan Lin, I found, on examining the astronomical sections of that work, a considerable number of observations of solar spots, extending over a period of 904 years, and, considering that some account of these ancient observations might be of interest to the Society, I have requested permission to lay before you a translation of them, in the hope that they may be of some service to such of the Fellows as may be more particularly engaged in the investigation of these peculiar phenomena.

The Encyclopædia of Ma Twan Lin is considered not only by the Chinese themselves, but also by such European Sinologists as have had occasion to refer to it, as a most remarkable and trustworthy work. Many eminent writers speak of it in the highest terms of approbation, and among these I take the opportunity of calling your attention to the opinion of Abel Remusat, the author of a well-known and excellent Chinese grammar, who, after giving, in that work, an account of a number of the best Chinese works on different subjects, concludes thus:—"And above all, the excellent work of Ma Twan Lin, entitled *Wan Heen Tung Kao*, the finest monument of Chinese literature, a vast collection of memoirs on all sorts of subjects, a treasure of erudition and criticism, in which all the materials that Chinese antiquity has left us, relating to their religion, legislation, rural and political economy, commerce, agriculture, government, natural history, physical geography, and ethnology, will be found, brought together, classed and discussed, in admirable order, method, and lucidity,—in short, a production which, as I have had occasion before to remark elsewhere, is in itself a complete library, and which, did their literature offer nothing else of value, would deserve that the Chinese language should be acquired, were it for no other purpose than to read this work."

My copy of this highly esteemed work is in 100 Chinese volumes. The matters treated of are arranged under 24 principal heads. These are divided into 348 sections or chapters, which have also numerous subdivisions. The astronomical portion consists of 17 chapters, Nos. 278 to 295 inclusive. The subjects treated of are—The general distribution of the stars in the heavens, comprising the asterisms in the three great spaces and the twenty-eight stellar divisions, the whole of which are

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enumerated and fully described; thus forming a complete Chinese catalogue of stars.

The degrees and mansions of the twelve zodiacal divisions follow, and it may be here observed that the ancient Chinese zodiacal names alone are given. The course of the Milky Way comes next, followed by a general account of the Sun, Moon, and five planets. Next we have extraordinary appearances in the stars and in the heavens generally; these, however, consist principally of accounts of halos and vapours or extraordinary configurations of the clouds.

These are followed by a long account of eclipses of the Sun, commencing with that recorded in the Shoo King, said to have occurred B.C. 2158, of which I gave an account in the *Monthly Notices*, vol. xxiii., and ending with one in A.D. 1223, the number being more than 600; some account of these may, if agreeable to the Society, form the subject of a future communication. We have next extraordinary appearances connected with the Sun, among which are the observations of solar spots, which form the subject of the present paper. These are followed by eclipses of the Moon and singular appearances connected with that body. Next are observations of comets. These have been translated in the work I lately published on Chinese Comets. Prognostications or astrological deductions from the motions and positions of the heavenly bodies come next, followed by observations of shooting or other moving stars; they extend from the Chow dynasty, which commenced B.C. 1122, to about A.D. 1230. After which we have accounts of stars seen in the day-time. These are principally *Venus* and *Jupiter*. Next, an account of auspicious stars, then of temporary stars, and lastly, of extraordinary halos and rainbows.

The observations of solar spots which form the subject of this paper extend from A.D. 301 to 1205, a period of 904 years. They, however, amount to but 45, a number which, considering the time over which they are spread, must appear very small. But it must be recollected that naked-eye observations of the solar spots must of necessity be of very rare occurrence, and, as there is no mention of the employment of coloured or smoked glasses to take off the glare of the Sun, they could only be made under the favourable circumstances of a fog, and the Sun rarely presents us with spots sufficiently large to be seen, even then, without optical assistance. Sir John Herschel, in his *Outlines of Astronomy*, remarks that, at least, on two occasions before the invention of telescopes, spots had been seen with the naked eye, and it appears evident to me that these were considered by him as occurrences of a very unusual kind. Here, however, in Ma Twan Lin's work, we have a record of 45 observations of these objects, some of which were seen for several days following. Many of these spots are recorded, as resembling plums of different kinds and sizes, and others are said to have been as large as a hen's egg, and one is mentioned as having

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resembled a duck. This may remind us of one of the observations of the late Capt. Shea, who describes a group of spots as being like a ship, and also of the drawing of a group of spots exhibited by Mr. Howlett some years ago, which bore a grotesque resemblance to a human skeleton. Most of the instances of their having been seen for several days in succession are within the bounds of possibility. One, however, which is said to have been seen for 19 days, could never have been observed for that length of time on account of the now well-known period of the rotation of the Sun, and it is singular that no conclusions were attempted to be drawn from the peculiar phenomena thus presented to their eyes, nothing of the kind being to be found in their writings.

These observations are continued in the supplement to Ma Twan Lin's Encyclopædia, published since the accession of the present dynasty in 1644, in which the subjects treated of in the former work are brought down to the date just mentioned. I have had no opportunity, lately, of consulting this work, but I have found in the history of the Ming dynasty, that which preceded the persent one, many observations of the solar spots, the latest being dated Nov. 29, 1638, only six years before the accession of the reigning dynasty, the Tsing. On the present occasion I shall confine myself solely to the observations contained in the original work of Ma Twan Lin. They are possibly of but little value in themselves beyond the mere fact that they were made by the Chinese astronomers at the dates specified, but I must here observe that, as it is stated in our astronomical works, that among Europeans, Galileo in 1610 was the first observer of the solar spots, it follows that the Chinese astronomers were far earlier in their observations of those remarkable objects. In fact, these very observations now placed before you were printed and published in the first edition of Ma Twan Lin's Encyclopædia, which edition appeared in 1322. I must also express my conviction, founded, after a careful and critical examination, on the peculiar appearance of the characters, the date 1322, the paper and other indications, that in the volumes in my possession, I have really a copy of the first edition of Ma Twan Lin's work,* in which opinion I

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* As, when this paper was read, some doubt was expressed as to the correctness of this statement, I take this opportunity of giving the reasons why I came to that conclusion. First, as respects the date 1322. Chinese books generally have the date at the end of the preface. When a second edition is published another preface is added to the preceding one with the date of the issuing of that edition. In the present instance there is a preface with a date which appears to be that of the *completion* of the work. This is followed by a summary of the arrangement of the subjects, at the end of which is another date evidently that of the *first publication*. That of the preface is said to be the first year of the Epoch 至大 Che Ta. That of the summary to be the second year of 至治 Che Che. On reference to the chronological tables appended to my work on Chinese comets, the epoch Che Ta will be found to be that of the Emperor Woo Tsung of the Yuen dynasty, commencing 1308, which is therefore the date of the completion of the work. Che Che is the epoch of a succeeding Emperor, Ying Tsung, which epoch commenced 1321, the second year of which is consequently 1322, the date of the

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am supported by the Rev. J. Summers, Professor of Chinese, King's College, London. Hence we find that these observations were published 288 years before Galileo's observations in 1610. I may also remark that, as these Chinese observations commence in A.D. 301, their astronomers had detected the spots in the Sun 1308 years before the assumed first discovery by Galileo. It must, however, be observed, that, previous to the commencement of the seventeenth century the intercourse between China and Europe was extremely limited, and little or nothing was known by Europeans either of the language, or of the general literature of that country until towards the close of that century. It was, therefore, next to impossible that Galileo could have known anything of what the Chinese had done so long before him, and he is therefore fully entitled to the credit given him by his contemporaries as regards the solar spots. These circumstances render these early observations of the Chinese historically curious; and if they have no other merit, they tend to establish the fact, with some appearance of certainty, that the physical constitution of the Sun has undergone little or no alteration since A.D. 301 to the present time, a period of 1572 years.

In extracting these observations I have confined myself merely to the year, month, and day of their occurrence. In the original we have the name of the Emperor and other particulars which are unimportant; all that is required being the correct date, which, in every instance, has been carefully reduced from the Chinese mode of expressing it, to our reckoning, by means of the tables I published in my work on Chinese cometary observations. To this I have added, where necessary, the incidental remarks relating to the appearance or size of any particular spot, and the number of days, on which it was visible. I have, however, left out the astrological deductions, as in several instances the death of an Emperor, or some other important personage, is said to have shortly followed the appearance of a spot. In short, I have rendered them as concisely as possible, and have only to express my hope that they may not be found entirely useless in the investigation of these remarkable phenomena.

publication. There is no other date to be found in the work. The characters, again, are peculiar, and appear to bear the same relation to those of more recent date, that the typography of the reigns of James I. or Charles I. does to that of the present time. The paper, also, is thicker and coarser than that since employed, and is not only in many instances extremely tender, but is also wholly wanting in that peculiar softness and silky feel which generally distinguish the paper of more recent times. Surprise was also expressed that books of that age should be in such good condition; but, as is well known, *our* early printed books are often to be met with in perfect preservation. I myself have books printed at the close of the fifteenth and beginning of the sixteenth centuries that are in excellent order, so that there is no great wonder that these Chinese volumes should also be in good preservation, particularly as they have evidently been recently very carefully mended, and put into good condition by having been rebound.

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Chinese Observations of Solar Spots from A.D. 301 *to* 1205, *extracted from the Encyclopædia of Ma Twan Lin*, vol. lxxxiii. chapter cclxxxiv.:—

A.D.		
301	October 20	
321	March 8	
322	March 11	
342	September 3	
354	November 7	Large, like a hen's egg.
355	April 4	Like a peach.
359	September 8	Like a hen's egg.
369	November 3	
370	March 29	Like a large plum.
372	November 30.	
373	November 26	Like a small plum.
374	April 6	Like a duck.
374	November 27	Like a hen's egg.
388	April 3	Like a small plum.
389	July 17	Like a small plum.
396	December 8	
400	December 24	
577	December 30	Like a cup.
826	March 25	
832	April 14	
837	December 15	Like a hen's egg.
841	December 31	
874	No month or day.	
974	February 2	
1077	March 6	Like a large plum.
1078	March 10	Like a plum. The text says seen for 19 days.?
1079	January 11	Like a plum. Seen for 12 days.
1079	March 28	Like a plum. Seen for 10 days.
1104	November 12	Resembling a date.
1112	May 3	As large as a chestnut.
1118	November 17	Like a large plum.
1120	July 31	Like a date.
1123	January 5	Like a large plum.
1129	April 21	
1129	December 16	
1131	March 12	Like a large plum. Seen for 3 days.
1136	November 24	Like a large plum. Seen for 10 days.
1137	February 27	Like a large plum. Seen for 10 days.
1138	March 17	Resembling a large date.
1138	November 26	
1186	July 22	Like a date.

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A.D.			
1193	December		
1200	August 23	Like a date.	Seen for 6 days.
1201	January 4	Like a date.	Seen for 12 days.
1205	February 7	Like a date.	Seen for 13 days.

A Geometrical Investigation of the Orbit of a Double Star.

By J. M. Wilson, Esq.

Having devoted spare hours occasionally to working out the orbits of double stars, I was led to endeavour to find a purely geometrical solution of the problem, "Given the orbit as projected on the plane of the sky, and the position in it of the star of reference, to find the inclination and position of the real orbit." It must be remembered, of course, that the actual orbit may be in any plane, and that the star of reference is assumed to be in its focus in that plane, but that when seen obliquely, the eccentricity of the orbit is in general changed, and the star always displaced from the focus of the projected ellipse. The problem, then, is to determine, from the amount of displacement of the focus, the position of the real ellipse. Herschel has given in the Astronomical Society's *Memoirs*, vol. v., analytical formulæ for this problem; that is, formulæ for computing the longitude of the node, the inclination of the orbit, and the angle of position of the perihelion; but, as far as I am aware, no elementary geometrical solution has been given.

Let S_1, S_2 . . . S_n, be positions of one star with reference to another star S at different dates, the angle being got directly from observation, and corrected by the interpolating curve, and the distance being computed therefrom by Herschel's method; and let the ellipse in fig. 1 be found to pass through, or as nearly as may be through them all. Find C the centre of this, the apparent ellipse. Join C S, and produce it to meet the ellipse in

Fig. 1